Self-Synchronization, the Future Joint Force and the United States Army's Objective Force

A Monograph
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Abstract

SELF-SYNCHRONIZATION, THE FUTURE JOINT FORCE AND THE UNITED STATES ARMY'S OBJECTIVE FORCE by MAJ Charles D Costanza, United States Army, 65 pages.

Self-synchronization is an idea that comes directly from Network-Centric Warfare but its foundations lie in complexity theory and the ideas of self-organization and emergent behavior. In order to understand self-synchronization the basics of complexity theory, specifically self-organization and emergent behavior, must be explained. Then, by expanding on the accepted definition of self-synchronization as defined by Admiral Cebrowski in his early literature on NCW it is clear that self-synchronization is a combination of complexity theory's ideas of self-organization and emergent behavior and information technology. Next, by comparing the requirements and conditions of self-synchronization against the conditions and requirements of JOW's Adaptive Command and Objective Force Battle Command it can be determined if the conditions and requirements exist in future Joint and Army command and control concepts to allow self-synchronization. From this comparison it is clear that self-synchronization (self-coordination in the 2003 *Defense Transformation Guidance*) is a feasible concept for future Joint and Army forces. In fact, current doctrine supports the ideas behind self-synchronization and current Objective Force experiments demonstrate self-synchronizing behavior.

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As a result of information technology and the current operational environment, the United States Army and the Joint Force are transforming themselves into networked organizations. Information technology promises shared situational awareness of the battlefield, increased dispersion and increased combat power. In 1998 Vice Admiral Arthur K Cebrowski initially described the concept of Network-Centric Warfare in his Naval War College lecture *Network Centric Warfare: An Emerging Response to the Information Age* and his article *Network Centric Warfare: Its Origins and Future*.[1] Cebrowski defined Network-Centric Warfare (NCW) as the emerging operational concept of war for the information age. NCW has also been called the enabling concept for Joint Vision 2020 and the basis for the concept of future joint operations.[2] NCW is possible because of information superiority provided by improved technology in the form of networked situational awareness (common operating picture or COP). This networked situational awareness improves speed of command, allows massing of effects (versus massing of forces), and collaboration among highly dispersed forces. The ultimate goal of NCW is self-synchronization: shared situational awareness that leads to shared situational understanding and allows forces to organize and synchronize from the "bottom-up". While much has been written about the concept of self-synchronization, academically and conceptually, little effort has been made in attempting to describe the requirements and conditions that allow self-synchronization in attempts to make the concept applicable to Joint and Army concepts of future operations.

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[1] See Vice Admiral Arthur K. Cebrowski, USN, *"Network Centric Warfare: An Emerging Response to the Information Age*", Presentation at the Command and Control Research Technology Symposium, Naval War College, 29 June 1999 and Vice Admiral Arthur K. Cebrowski, USN and John J. Garstka, "*Network Centric Warfare: Its Origins and Future*," *US Naval Institute Proceedings*, 124, no.1., January 1998, 28-35.

[2] The *2001 Department of Defense Network Centric Warfare Report to Congress* indirectly states the requirement for the Services to adopt the concepts of NCW in order to satisfy the requirements of JV2020.

METHODOLOGY

In order to determine if self-synchronization can be applied to the Army's Objective Force and the future Joint force the origins of self-synchronization need to be understood. Next the conditions and requirements that make self-synchronization possible must be clearly defined in order to compare those conditions and requirements with future Joint and Army command and control concepts.

While self-synchronization is a concept that comes from Network-Centric Warfare, its foundations lie in complexity theory and the ideas of self-organization and emergent behavior. Chapter 1 provides a simple description of the basics of complexity theory specifically complex adaptive systems. It then applies the properties and mechanisms of complex adaptive systems to the Army. The chapter then describes two key concepts of complexity theory that are specific to CAS and are the foundation of the concept of self-synchronization – self-organization and emergent behavior. The chapter concludes by providing a historical example from World War II that illustrates self-organization and emergent behavior and the concepts that make them possible are not new ideas to the Army.

Since self-synchronization is a term that is specific to the theory of Network-Centric Warfare, Chapter 2 provides a description of NCW. NCW, although not using that terminology, was demonstrated by the Army in the early 1990's through its Force XXI concept. Chapter 3 expands on the accepted definition of self-synchronization as defined by Admiral Cebrowski in his early literature on NCW and shows that self-synchronization is a combination of complexity theory's ideas of self-organization and emergent behavior and information technology. The chapter takes current research, including the Advanced Command and Control Studies conducted by the Chief of Naval Operations Special Assistant for Strategic Planning (N6C), and literature on self-

synchronization to determine what conditions and requirements allow self-synchronizing behavior. These conditions and requirements will be used to compare self-synchronization to future Joint and Army operational concepts to determine if self-synchronization is feasible. The chapter concludes by showing that the Army demonstrated the capability of self-synchronizing behavior during the Division Capstone Exercise in 1998.

In order to compare self-synchronization to future Joint and Army command and control concepts to determine its feasibility, an understanding of the future Joint and Army operational concepts and the command and control concepts that are required to execute those operations is required. Chapter 4 describes the future Joint Operational Warfighting (JOW) concept and the future Joint command and control concept, Adaptive Command. Chapter 5 describes the Objective Force operational concept from the Unit of Action & Unit of Employment Operational & Organizational documents as a lead in to a description of the command and control concept that is required to execute Objective Force operations – Objective Force Battle Command.

The final chapter compares the requirements and conditions of self-synchronization against the conditions and requirements of JOW's Adaptive Command and Objective Force Battle Command to determine if the conditions and requirements exist in future Joint and Army command and control concepts to allow self-synchronization. The chapter concludes by discussing potential issues with implementing command and control concepts that allow self-synchronization, including recommendations for further study.

CHAPTER 1 - COMPLEXITY THEORY

Newtonian thinking, as the name suggests, was a product of the scientific revolution. It is based on linear causation – simple, measurable, cause and effect. Because of linearity, systems were understood to be predictable and controllable. In the early 20th century, scientists became dissatisfied with the Newtonian way of looking at things because it failed to explain the behavior of complex systems, specifically the behavior of complex natural systems.[3] Breaking these complex systems down into their component parts did not explain the behavior of the overall system. The linear Newtonian way of looking at things did not work. The behavior of these complex systems was more than just the "sum of the parts". Not only did Newtonian thinking not work with natural systems it failed to explain the behavior of complex systems in other disciplines. The behavior of economies and societies could not be explained with linear Newtonian logic. Physicists, biologist, anthropologists, geneticists, and even mathematicians realized that Newtonian thinking did not adequately explain complex system behavior.[4] The search for a new paradigm to explain the behavior of these complex systems, systems that did not behave according to linear Newtonian rules, led to the development of complexity theory.

[3] Complexity theory can be traced back to 1892 when astronomer Henri Poincare discovered that certain orbits of three or more interacting celestial bodies exhibited unstable and unpredictable behavior (beginnings of nonlinear dynamics). In 1948 John Von Neumann attempted to abstract the logical structure of life (self-reproducing automata). The popularly recognized beginning of complexity theory is 1984 with the foundation of the Santa Fe Institute for the interdisciplinary study of complex systems. The complete history of nonlinear dynamics and complexity theory is described in Andrew Ilachinski's *Land Warfare and Complexity, Part I: Mathematical Background and Technical Sourcebook* pages 21-23 and 62-63.

[4] Andrew Ilachinski, *Land Warfare and Complexity, Part I: Mathematical Background and Technical Sourcebook* (Alexandria, VA: Center for Naval Analysis, July 1996), 15.

Complexity theory, based on systems theory, is about ***interactions*** the results of which can not be explained in terms of linear cause and effect.[5] Understanding the premise of complexity theory is not complex.[6] A complex system is made up of many sub-systems (or agents). These sub-systems are open systems, meaning they receive feedback from their interactions with other sub-systems and their environment. It is these sub-system interactions that explain complex system behavior.[7] A complex system adapts based on the feedback from its interactions. It is this adaptation caused by interactions at all levels of the system that creates complexity.[8] Because these interactions create nonlinear effects (behaviors) a complex system does not appear orderly.[9] Its behavior is difficult to anticipate or predict. Because of adaptation, system behavior can not be explained in the simple Newtonian terms of cause and effect.[10] A complex system may come close to equilibrium but because of its interactions and the nonlinearity those interactions create it can not reach it. At the same time its overall behavior is not chaotic – it is specific, describable, and productive – it has visible purpose and direction.[11] Complexity is the boundary between order, as defined by

[5] Complexity theory is about nonlinearity. In nonlinear systems small changes in key variables can cause big changes and unexpected events (hence nonlinear). Nonlinearity can be understood in terms of feedback generated by interactions. Interactions between system component's cause changes and these changes generate feedback which can be positive or negative. Positive feedback amplifies the change and negative feedback suppresses the change.
[6] Modeling the behavior of a complex system, the nonlinearity created by interaction at all the different levels of a complex system, makes complexity theory complex. For example, genetic scientist John Holland has written several books that attempt to explain how to model complex system behavior without returning to Newtonian explanations of linear causality.
[7] M. M. Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos* (New York: Simon and Schuster, 1992), 11.
[8] John Holland, *Hidden Order: How Adaptation Builds Complexity* (Cambridge, MA: Perseus Publishing, 1996).
[9] Waldrop, 11-12.
[10] John F. Schmitt, "Command and (out of) Control: The Military Implications of Complexity Theory," *Complexity, Global Politics, and National Security*, ed. David D. Alberts and T.J. Czerwinski (Washington, D.C.: National Defense University, 1997), 9.
[11] Colonel James K. Greer, "Operational Art for the Objective Force," *Military Review*, September-October, 2002, 27.

Newtonian equilibrium, and chaos.[12] Because of feedback and interactions among subsystems and between subsystems and their environment many complex systems change – they adapt in order to maximize these interactions to their advantage and, as a result, ***control of these complex systems is dispersed among its subsystems*** [13]

Complex adaptive systems (CAS) are characterized in terms of properties and mechanisms that when combined allow adaptation. In order to understand how to control complex systems the properties and mechanisms of complex adaptive systems must be understood. The four properties that are typically used to describe CAS are aggregation, nonlinearity, information flows and diversity.[14] These four properties are based on the discussion above on subsystem interactions and feedback. The three mechanisms typically used to describe CAS are tagging, building blocks and internal models.[15] Tagging is the mechanism that allows CAS to identify other subsystems. Building blocks are the basics that allow CAS to develop internal models. Internal models are "rules", based on building blocks, ***which allow CAS to anticipate and predict events in their environment***.[16] Feedback from other subsystems and the environment allow CAS to modify building blocks and develop new building blocks if needed thus improving internal models autonomously.[17]

Understanding these three mechanisms depends on the basic understanding that low level subsystem interactions determine overall CAS behavior. This concept is known as emergence. Building blocks and internal models are developed based on those interactions. Another key to understanding these properties and mechanisms is

[12] U.S. Joint Forces Command, J9 Futures Lab, Project Alpha, *Complexity Science and Joint Operational Warfighting (Draft)*, 13 June 2002, 3.
[13] Waldrop, 145.
[14] Ilachinski, 99-100.
[15] Ibid.
[16] Ibid.
[17] Waldrop, 179.

that CAS have many levels of organization and that subsystems of a complex adaptive system may be complex adaptive system themselves, also made up of many other complex adaptive systems.[18] The ability of complex systems to adapt, using the above properties and mechanisms, allows them to demonstrate two central and related concepts of complexity theory – self-organization and emergence.

Self-organization is the ability of a system to autonomously change its basic ***structure*** based on the interactions of its subsystems and the changes they autonomously make to their structure.[19] A system's experience, based on feedback from its interactions with other systems and its environment, allows it to discover new, more efficient ways of doing things, causing it to make changes in its structure (organization).[20] A system changes or creates new building blocks based on interactions which in turn cause it to modify its internal models. Common understanding of overall system goals or purpose (vision) must exist in order to provide some framework for discovery and determination of efficiency that prompt subsystem change.[21] Based on this description of self-organization the following mechanisms must exist:

1) System must be an open system consisting of:
2) Many parts (and those parts also consist of many parts) which allows:
3) Local interaction which allows:
4) Dynamic behavior (adaptation made possible by common goal or vision and communicated through common building blocks or internal models) which creates:
5) Nonlinear dynamics and
6) Emergent behavior[22]

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[18] Waldrop, 145.
[19] Ibid, 11.
[20] Ilachinski, 66.
[21] Robert R. Maxfield, "Complexity and Organization Management," Complexity, Global Politics, and National Security, ed. David D. Alberts and T.J. Czerwinski (Washington, D.C.: National Defense University, 1997), 9.
[22] Ethan H. Decker, *Self-Organizing Systems* (Albuquerque: Department of Biology, University of New Mexico), < http://algodones.unm.edu/~bmilne/bio576/instr/html/SOS/sos.html> Accessed 23 September 2002, 3-8.

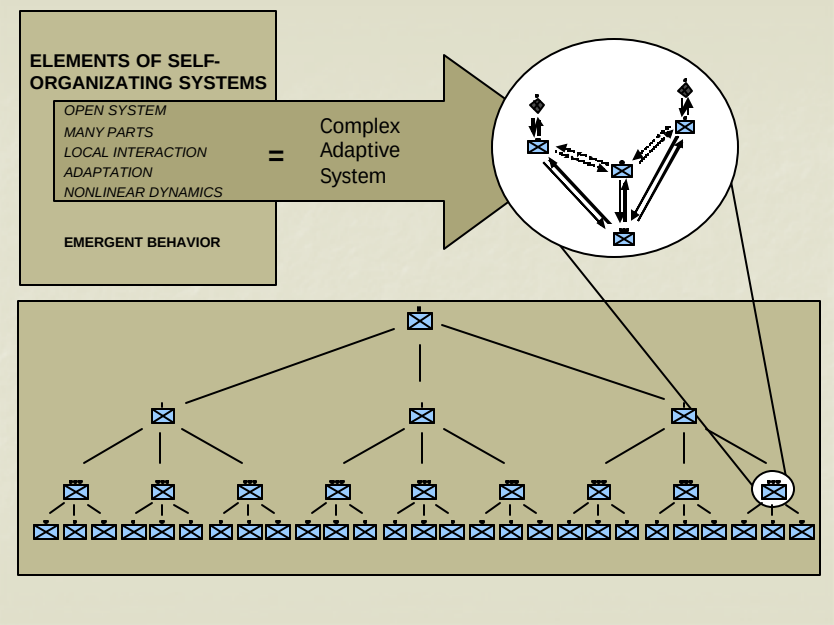

FIGURE 1: SELF-ORGANIZATION

As a result of self-organization of complex systems, ***control of an organization is typically distributed over the whole of the system***. Self-organization, in essence, allows an absence of direct centralized control.[23]

Emergence is about overall system ***behavior*** and is perhaps the central concept of complexity theory – one that prompted scientists to begin questioning Newtonian thinking in the first place. Emergence is the behavior of a system that is created out of the interactions of its sub-systems (understanding they may be complex systems as well – adding to the complexity of the interactions and explanation of overall system behavior). Interactions create behavior at one level. This behavior creates building blocks for the next level, whose interactions create behavior that provides the building

[23] Francis Helighen, *The Science of Self-Organization and Adaptivity*, <http://www.pespmc1.vub.ac.be/Papers/EOLSS-Self-Organiz.pdf> Accessed 23 September 2002, 5. Decker further explains this decentralized control by saying "The essence of self-organization is that system structure often appears without explicit pressure or involvement from outside the system. In other words, the constraints on form (i.e. organization) of interest are internal to the system, resulting in the interactions among the components and usually independent of the physical nature of those components…" Decker, 13.

blocks for the next level, etc. ultimately creating an overall system behavior.[24] Because emergent behavior comes from the "bottom-up" it is difficult to predict and, depending on the level of complexity, almost impossible to control.[25] ***Similar to self-organization, conditions can be set that help guide emergent behavior in systems: common sense of purpose that guides subsystem-behavior, common "building blocks" that create common "internal models" or rules that in turn guide system reactions to external feedback***.[26]

War is inherently complex and this complexity comes from the interaction of the actors that participate in it. These actors are themselves complex adaptive systems that are trying to force their opponent into either equilibrium, where they are no longer able to adapt or change based on their interactions and are destroyed, or out of complexity and into chaos.[27] The concepts of self-organization and emergence are useful metaphors when applied to organizations since organizations are complex adaptive systems, displaying the properties and mechanisms of CAS. A simple way to illustrate the United States Army as a complex adaptive system is to compare it to the commonly accepted properties and mechanisms of CAS as described above.[28]

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[24] John Holland, *Emergence: From Chaos to Order* (Cambridge, MA: Perseus Publishing, 1998), 122.
[25] Ilachinski, 187.
[26] Holland, *Emergence*, 238.
[27] Greer, 27.
[28] As Greer and Ilachinski have done.

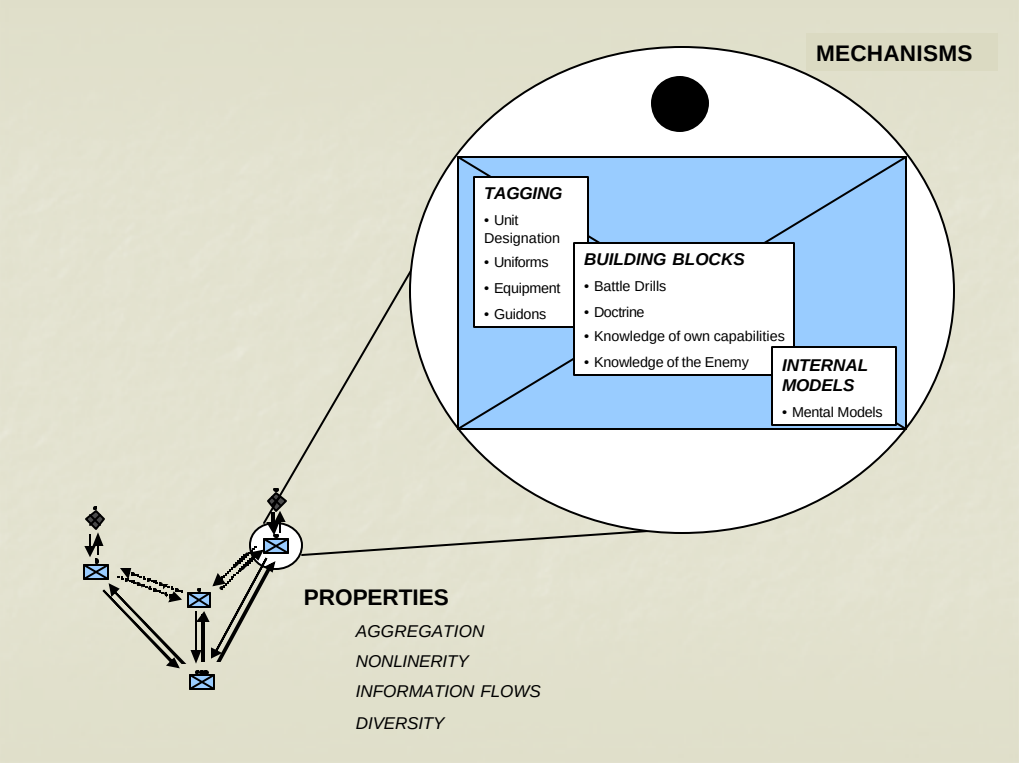

FIGURE 2: COMPLEX ADAPTIVE SYSTEM (CAS)

The Army displays all the properties and mechanisms of a CAS. For example aggregation is made possible by the Army's force structure that allows it to combine smaller systems (units) into larger systems (units). Tagging is accomplished through unit designations which reflect unit capabilities or uniforms or even equipment.[29] Examples of building blocks are battle drills and doctrine. Internal models are mental models based on building blocks. Because of the interactions on the complex battlefield, interactions among friendly units, enemy units and the environment, the Army is a ***nonlinear*** system.[30] Military operations are inherently complex and this complexity is a result of the interactions of units with other friendly and enemy units (subsystems) and

[29] Service or unit culture is another example of tagging within military organizations.
[30] Greer, 28.

the environment (time, space) on many different levels. Complexity theory's premise, based on self-organization and emergence, is that complex enterprises that require adaptation (decision) are best organized from the bottom-up.[31]

HISTORICAL EXAMPLE: THE 4TH ARMORED DIVISION IN WORLD WAR II

The 4th Armored Division Commander during the early part of World War II, Major General John "Tiger Jack" Wood, understood the power of decentralized command and control. Because of this understanding General Wood was able to develop an environment within the 4th Armored Division that maximized the potential of decentralized command and control. He was able to set overall boundaries that allowed self-organization and guided emergent behavior. Because of Wood's understanding of the power of "bottom-up" command and control the 4th Armored Division provides a simple, historical example of a military organization as a complex adaptive system demonstrating self-organization and emergent behavior.

Upon landing in Normandy the 4th Armored Division was able to move over 1057 miles in its first thirty days of combat.[32] Its two combat commands, Combat Command A (CCA) and Combat Command B (CCB) often operated independently, sometimes separated by distances of over 200 miles.[33] In its advance across Britinany the 4th Armored Division created a thirty mile penetration in the German defenses defeating the 77th, 91st and 243d German Infantry Divisions, the 5th Parachute Division, the 2d SS Panzer Division and destroying the 6th Parachute Division.[34] These examples of the 4th

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[31] Vice Admiral Arthur K Cebrowski, *Network Centric Warfare: An Emerging Response to the Information Age*, Presentation at the Command and Control Research Technology Symposium, Naval War College, 29 June 1999, 6-7.
[32] Committee 13, Armor Officers Advanced Course, *Armor in the Exploitation: The Fourth Armored Division Across France to the Moselle River*, (Fort Knox, KY: The Armored School, May 1949) 61.
[33] Hanson W. Baldwin, *Tiger Jack* (Ft. Collins, CO: The Old Army Press, 1979) 66-67.
[34] Committee 13, 23.

Armored Division's rapid, decisive, decentralized performance are examples of emergent behavior – the overall behavior of the system (the 4th Armored Division) was the result of interactions of its sub-systems (its subordinate units) with each other and their environment. Its overall emergent behavior was produced from the "bottom-up". The conditions (common boundaries) that allowed the 4th Armored Division to display emergent behavior were: a common understanding within the Division created by its use of mission orders, clear commander's intent, and trust developed during training. These same conditions also allowed the 4th Armored Division to self-organize - quickly changing its task organization based on the situation it faced.

Major General John Wood's use of verbal mission orders provided general boundaries for the Division and a common sense of purpose which was provided by Wood's clear commander's intent.[35] Wood believed in the importance of speed of command and mission orders which allowed his Division to execute faster than its opponents and quickly adapt based on the situation because those closest to the complexity, the "interactions" were empowered to make decisions – "to adapt". As a result of Wood's verbal mission orders the 4th Armored Division would routinely have accomplished its missions prior to the written Corps order arriving at the Division command post.[36] There are many examples of the speed and flexibility that mission orders gave the 4th Armored Division. During one Division operation to seize bridge crossings over the Selune River in France Combat Command A's commander, Colonel Bruce Clarke, was able to re-task organize his combat command into four separate task

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[35] An example of Wood's mission orders: Complete 4th Armored Division order for 21 December 1941. "4 AD atks on Corps O to overcome and destroy all en resistance encounterd in Z and will protect left flank of Corps. CCA will move from present positions during night D-1 – D to atk pos N of ARLON. Atk on O at H-hour, overcome en in Z. Maintain contact with 26 INF Div on right. CCB from present posn assist in screening movement of CCA and Arty into atk posns. Atk on O, overcome and destroy en in Z." Committee 4, Armor Officers Advanced Course, *Armor at Bastogne* (Fort Knox, KY: The Armored School, May 1949) lix.

[36] Baldwin, 42.

forces and begin movement within an hour after receipt of Wood's order.[37] Another example was the Division's encirclement of Nancy where the Division was able to quickly change the direction and nature of a limited breakthrough into a deep attack to interdict German lines of communication.[38]

The Division's ability to successful execute mission orders was only possible through trust and a common understanding developed during training. Trust and common understanding were boundaries Wood used to guide emergent behavior of the Division. Major General John Wood developed this "common understanding" for the 4th Armored Division early in its training. Wood did not believe in a rigid task organization believing it took away flexibility and speed of action. During the Division's training there was no set task organization – "battalions were traded off one for another, added to or taken away from combat commands in the middle of the training exercise till we learned to make these switches with no dimunition of effectiveness."[39] This method of task organizing the Division created a familiarity and friendship among the subordinate units brought about by common striving for a common purpose causing them to think with a "single mind".[40] The 4th Armored Division's ability to change task organization based on the situation even during execution, its ability to self-organize, was possible because of common purpose, simple rules and trust created during training.

Although the terms complexity theory and complex adaptive system would not have been familiar to General Wood, he believed that in order to maximize speed of command and combat power on a dispersed battlefield he had to use decentralized

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[37] Donald E Vandergriff, "Before There was Digitization: How MG J.S. Wood's 4th Armored Division Stormed Across France Without Written Orders," *Armor Magazine*, September-October 2000, 24.
[38] Christopher R. Gabel, *The 4th Armored Division in the Encirclement of Nancy* (Fort Leavenworth, KS: Combat Studies Institute, 1986) 25.
[39] Baldwin, 145.
[40] Vandergriff, 21.

command. He clearly understood the boundaries needed to create the conditions that resulted in the 4th Armored Division's emergent behavior and its ability to self-organize. In his memoirs Wood wrote:

> Contrary to the practice in many other armored divisions, we had no separation into fixed or rigid combat commands. To me the division was a reservoir of force to be applied in different combinations as circumstances indicated, and which could be changed as needed in the course of combat by a commander in close contact with the situation at the front. These is no time or place for detailed orders, limiting lines or zones, or other restraints....It must drive fast and hard in given directions in columns of all arms with the necessary supply maintenance, and supporting elements present in each column, ready for action to the front or toward the flanks...Each column was self-sustaining for prolonged action....[41]

Complexity theory developed from the realization that Newtonian thinking, while applicable to simple linear systems that move toward a steady state or equilibrium, failed to adequately explain the behavior of complex systems. Complex system behavior was not chaotic, it moved with an overall purpose, but it was also not linear. Complex system behavior adapted from some "hidden order" emerging from the interactions of its smallest subsystems.[42] A key concept that complexity theory has provided through explaining this emergent behavior is self-organization. The military by its nature is a complex adaptive system and the principles that create self-organization and allow emergent behavior in complex adaptive systems have utility in command and control as illustrated by General John Wood. Network-Centric Warfare with its promise of shared awareness of the battlefield and almost instant universal communication, both provided by information technology, takes the concepts of self-organization and emergence in CAS and creates the possibility for an even more powerful and useful concept - self-synchronization.

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[41] Wood's memoirs quoted by Baldwin, 156.
[42] From the title of Holland's book - *Hidden Order*.

CHAPTER 2 - NETWORK CENTRIC WARFARE

A basic understanding of Network Centric Warfare (NCW) and its characteristics is required in order to understand the concept of self-synchronization since self-synchronization is a product of NCW theory.[43] Network Centric Warfare has been called the "emerging theory of war for the information age".[44] It has also been called the enabling concept for Joint Vision 2020 and the basis for the concept of future joint operations.[45] Network Centric Warfare, like complexity theory, is a simple concept.[46] It uses emerging information technology to network the component parts of a highly dispersed military organization, promising increases in speed of command and combat power.[47] The networked infostructure alone is not responsible for increasing speed of command or generating increased combat, but is the vehicle that allows the characteristics of NCW to be possible.[48]

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[43] Self-synchronization is a term that is specific to Network Centric Warfare. It is not found in complexity theory literature or in the literature discussing future Joint and Army warfighting concepts.

[44] Lieutenant Commander Matthew A. Kosnar, "*Self-Synchronization-The Next Step*" (Newport, RI: Naval War College, 4 February 2002), 4.

[45] Lieutenant Commander James K Kuhn, "*Network Centric Warfare: The End of Objective Oriented Command and Control?*" (Newport, RI: Naval War College, 13 February 1998), abstract. The 2001 Department of Defense Network Centric Warfare report to Congress indirectly states the requirement for the Services to adopt the concepts of NCW in order to satisfy the requirements of JV2020.

[46] While the concept of NCW may not be difficult to understand, application of Network Centric Warfare is where the difficulty comes in. Adapting NCW and maximizing its capability requires fundamental changes to Army culture, doctrine, training, and leader development. While the Army had an appendix in the 2001 Department of Defense Network Centric Warfare Report to Congress that laid out its plan for adaptation of NCW concepts the term is not included in current Army doctrine or is it in the latest operational & organizational documents for the Objective Force. The concepts of NCW can be seen as early as 1994 with the concepts behind Force XXI. See *TRADOC Pamphlet 525-5*, *Force XXI Operations*, Chapter 3.

[47] David S. Alberts, J.J. Garstka, and F.P. Stein, *Network Centric Warfare: Developing and Leveraging Information Superiority, 2d ed., rev.* (Washington, D.C.: National Defense University, 1999), 93

[48] Office of the Secretary of Defense, *Network Centric Warfare: Department of Defense Report to Congress* (Washington, D.C.: Government Printing Office, 27 July 2001), 3-14.

NCW characteristics according to the 2001 Department of Defense report to Congress on Network Centric Warfare are:

1) ***A secure and seamless connectivity provided by a physical network (infostructure)***. This network allows the capability to collect; share and access information which makes shared situational awareness possible.

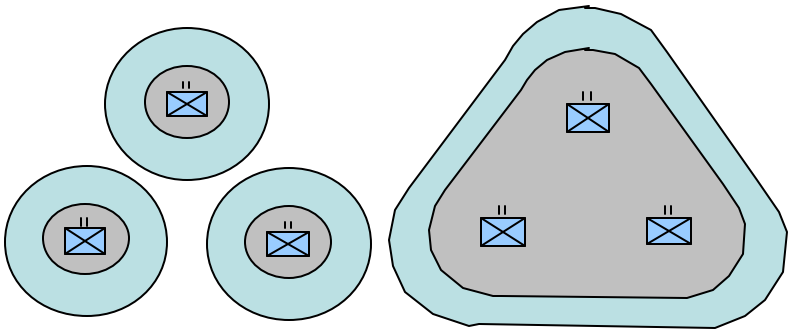
2) ***Shared situational awareness.*** Situational awareness is having knowledge in the form of information. Shared situational awareness allows collaboration and the ability of the force to universally understand the commander's intent, ensuring unity of effort.[49]

3) ***Increased speed of command***. Improved connectivity provided by the network allows collaboration and shared commander's intent which dramatically increases speed of command.

4) ***Increased combat power***. The first three characteristics of a NCW force increase combat power by increasing the tempo of operations, responsiveness of the force and increased combat effectiveness.[50] Forces can operate in a more dispersed manner and because of the connectivity provided by the network they can mass effects.[51]

[49] David S. Alberts, J.J. Garstka, R.E. Hayes and D.A. Signori, *Understanding Information Age Warfare* (Washington, D.C.: Department of Defense Command and Control Research Program, 2001), 17-21
[50] Office of the Secretary of Defense, 3-9 – 3-10.
[51] Allen & Hamilton Booz Inc., *Volume I: Measuring the Effects of Network-Centric Warfare* (McLean, VA: Booz, Allen & Hamilton Inc., 28 April 1999), ii.

The figure below is an illustration of how NCW increases combat power. Light blue is sensor range and grey is weapons range.



52

FIGURE 3: COMBAT POWER AND NCW

The above characteristics of NCW are possible only when an organization changes from a purely hierarchical force structure where control is imposed from the top:

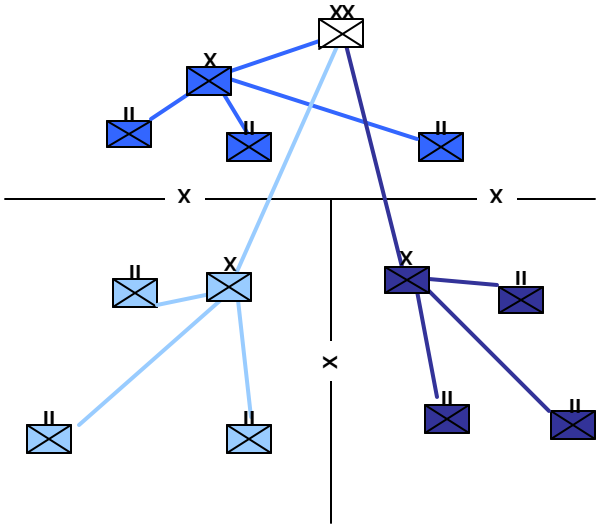


FIGURE 4: HIERARCHICAL FORCE STRUCTURE

To a networked force structure like this:

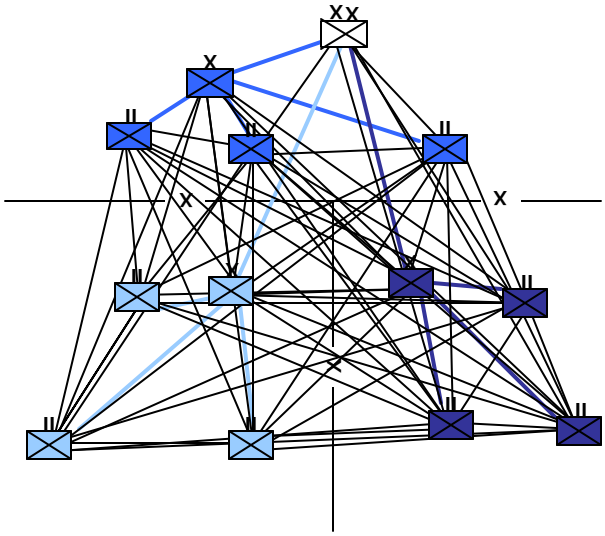


FIGURE 5: NETWORKED FORCE STRUCTURE

With a network-centric force any node (system) has the ability to use the capabilities of any other node in the network.[54] All weapons systems and sensors are available to all other systems.[55] Synchronizing the activities of this force can be generated from any node. Apply complexity theory to the NCW force model, specifically the concepts of self-organization and emergent behavior, it is clear that the behavior of an organization can

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[52] Adapted from Alberts, *Network Centric Warfare: Developing and Leveraging Information Superiority*, 102.
[53] Booz, 1-1.
[54] Increases in combat power can also be illustrated using Metcalf's law states that the power of a network increases in proportion to the square of the number of nodes on the network. For example, if you have four nodes, or platforms, on a network, its power would be 4^2, or 16. If you added on addition node, or platform, then the value would increase to 5^2, or 25.
[55] Booz, v-vi.

be influenced and perhaps even controlled without detailed top-down instructions.[56] NCW facilitates the decentralization of command. [57]

Complexity theory is useful in explaining the behavior of a network-centric military force. A complex adaptive system, like an Army platoon, is now interconnected by a network within the overall complex adaptive system of a joint task force. It now has shared situational awareness of the interactions of all other complex adaptive systems within the JTF. It also now has access to the combat power of all the different complex adaptive systems (platforms, units) of the JTF available. Because of the network, a platoon has the same understanding of the commander's intent as every other unit / system within the JTF. Because of the network, the platoon also has the same situational awareness of the battlefield as every other unit / system / commander within the JTF. As a result, the platoon can quickly and effectively mass the effects of close air support, artillery and other systems of the JTF on a target within the bounds set by the JTF commander.[58]

FORCE XXI AND THE DIVISION ADVANCED WARFIGHTING EXPERIMENT

The concepts of Network Centric Warfare can be seen in the Army as early as 1994 with the ideas behind Force XXI as can be seen in statements on the Army's future vision of battle command from TRADOC Pamphlet 525-5, *Force XXI Operations*. The new Army Battle Command System (ABCS) concept provided the network that allowed

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[56] Alberts, *Network Centric Warfare: Developing and Leveraging Information Superiority*, 160.

[57] According to Kuhn "Only the mission-oriented approach is fully supportive of network-centric warfare. The use of mission type directives by headquarters leaves the promulgation of detailed plans to local commanders. The result is that the lowest echelon possible is required to develop and execute tactical plans. Further, as the dynamic interaction in the battlespace unfolds, it is the local commander who again is empowered to adjust his plans and reallocate resources as required. The decentralization of command and control creates a flexible command structure which is able to effectively use the high speed of C4 to generate a rapid pace of battle… latitude [is] afforded the commanders to meet local threats as they occur, without relying on higher headquarters to assess the situation and issue new orders or objectives." Kuhn, 15.

[58] If the JTF is networked to a higher HQs the platoon may have even greater capabilities available to it.

shared situational awareness in the form of a common operating picture (COP). "ABCS…recognizes the inevitable coexistence of both hierarchical and nonhierarchical, or internetted, information processes."[59] The COP provided "Collective unit images [that] will form a battlespace framework based on shared, real-time awareness of the arrangement of forces in the battlespace…This system permits commanders at every level to share a common, relevant picture of the battlefield…"[60] The power of network centric warfare was seen in the ability of "***Individual soldiers…empowered for independent action because of enhanced situational awareness, digital control, and a common view of what needs to be done***."[61]

In November 1997 the United States Army conducted the Division Advanced Warfighting Experiment (DAWE) at the National Training Center which demonstrated the potential of Network Centric Warfare using the concepts and force design of Force XXI. During the DAWE three key observations were made about unit performance:

- Speed of command increased dramatically. Division level planning time was reduced from 72 hours to 12 hours. Company level planning was cut in half from 40 to 20 minutes because of share situational awareness and collaboration provided by the network.
- Ability to quickly mass combat power increased dramatically as demonstrated through the networked ability to call for indirect fire. Speed of calls for fire, including processing time, was reduced from three minutes to thirty seconds.[62]
- Final results from the National Training Center rotation showed that the division destroyed twice the number of enemy combat systems in half the time with a

[59] U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-5: Force XXI Operations* (Fort Monroe, VA: TRADOC, 1 August 1994), 3-4.
[60] Ibid
[61] U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-5: Force XXI Operations*, 3-5.
[62] Office of the Secretary of Defense, 8-21.

three fold increase in battlespace and with a force that had 25% less combat power.[63]

Increased situational awareness provided by the network was demonstrated at all levels. At the platoon level, platoon leaders stated that increased situational awareness allowed them to spend less time keeping track of friendly unit locations, allowing them to focus on the close battle.[64] At the company and platoon levels, increased situational awareness of friendly and enemy locations allowed commanders to wait until they deployed their force (before advantages of situational awareness these commanders had to deploy their forces early, reducing tempo).[65] Commanders at the company and battalion level reported that they were able to conduct more complex maneuvers with less risk because of shared situational awareness provided by the network.[66] Commanders at the brigade and division level said that increased situational awareness provided by the network allowed them to maximize the effects of the unit's combat power.[67] Because of increased situational awareness by the network during the DAWE the division was able to maximize the potential of decentralized command. More emphasis was placed on the commander's intent and mission orders which in combination with networked situational awareness allowed platoons and companies to "operate near autonomously".[68]

The information technologies that create the network provide a shared situational awareness of the battlefield, shared understanding of commander's intent and the ability to access any capability of the force from any node. The advantages of this network technology combined with an understanding of the behavior of complex adaptive

[63] Alberts, *Network Centric Warfare: Developing and Leveraging Information Superiority,* 181.
[64] Office of the Secretary of Defense, 8-22.
[65] Ibid.
[66] Office of the Secretary of Defense, 8-23.
[67] Ibid.
[68] Alberts, *Network Centric Warfare: Developing and Leveraging Information Superiority,* 177-178.

systems, specifically self-organization, creates the possibility of maximizing speed of command and combat power by allowing units to operate almost autonomously and coordinate among themselves within the bounds set by the commander. Force XXI envisioned this concept nine years ago with "better informed soldiers, capable of individual action within the overall command intent."[69] This Network Centric concept of an "altered notion of control" which is inspired by complexity theory and made possible by the connectivity provided by the network is known as self-synchronization.[70]

[69] U.S. Army Training and Doctrine Command, TRADOC Pamphlet 525-5: Force XXI Operations, 3-5.
[70] Alberts, Network *Centric Warfare: Developing and Leveraging Information Superiority*, 82.

CHAPTER 3 - SELF-SYNCHRONIZATION

Synchronization is "the meaningful arrangement of things or effects in time and space."[71] Army doctrine defines synchronization as "the arrangement of military actions in time, space, and purpose to produce maximum relative combat power at a decisive place and time."[72] As a result of Newtonian thinking synchronization has turned into a mechanistic process, the synchronization matrix being an example. The Network Centric Warfare idea of self-synchronization is nothing more than taking the "bottom-up" ideas of self-organization and emergence from complexity theory and adding the capabilities provided by information technology. It is the ability to achieve "synchronized results by **emergent behavior**."[73] Self-synchronization is actually a term that is specific to Network Centric Warfare, possible only because of the connectivity provided by information technology.[74] David S. Alberts describes self-synchronization as the most mature level of NCW made possible by adoption of new enabling command concepts that maximize its potential.[75] Self-synchronization is the utopian vision of Network Centric Warfare promising unparalleled increases in speed of command and combat power made possible by nonlinear thinking. A simple definition of self-synchronization is "the ability of a well-informed force to organise and coordinate complex warfare from the

[71] Alberts, *Understanding Information Age Warfare*, 28-29.
[72] U.S. Department of the Army, *Field Manual 101-5-1, Operational Terms and Graphics* (Washington D.C.: Department of the Army, 1997) 1-155.
[73] Alberts, *Network Centric Warfare: Developing and Leveraging Information Superiority*, 50.
[74] Self-synchronization is a term that is specific to NCW. It is only found in literature on NCW because it is possible only because of the network provided by information technology even though its foundations are based on self-organization and emergence from complexity theory.
[75] Alberts, *Network Centric Warfare: Developing and Leveraging Information Superiority*, 86-87.

bottom up."[76] The mostly widely quoted definition of self-synchronization comes from Network Centric Warfare literature written by Vice Admiral Arthur K. Cebrowski:

> Self-synchronization is the ability of a well -informed force to organize and synchronize warfare activities from the bottom-up. The organizing principles are unity of effort, clearly articulated commander's intent, and carefully crafted rules of engagement. Self-synchronization is enabled by a high level of [knowledge of] one's own forces, enemy forces, and all appropriate elements of the operating environment. It overcomes the loss of combat power inherent in top-down command directed synchronization characteristics of more conventional doctrine and converts combat from a step function to a high-speed continuum.[77]

Understanding self-synchronization requires an understanding of the "bottom-up" concepts of self-organization and emergent behavior discussed in Chapter One and an understanding of Network Centric Warfare. In order to understand self-synchronization we need to understand the key elements that make it possible and how we maximize those elements through adapting our command and control mechanisms to maximize its potential.

The key mechanisms that make self-synchronization possible are based on complexity theory and have been described by the authors of Network Centric Warfare as: two or more networked systems, shared awareness, a rule set, and a value adding interaction[78]. A rule set (internal model) is a set of "building blocks" that allow a system to make decisions in various operational situations based on their interactions (feedback). A value adding interaction is an interaction that helps modify behavior through adaptation by modifying the rule set. A rule set and value adding interaction are the same elements that make self-organization in CAS possible. The combination of shared awareness and a rule set is what allows subsystems to operate without

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[76] Scholz, Dr. Jason B. and Dr. Darren J Sutton, *Synchronization and the Networked Force*, <http://www.dodccrp.org/2000ICCRTS/cd/papers/Track4/051.pdf> Accessed on 23 September 2002, 3

[77] Vice Admiral Arthur K. Cebrowski and John J. Garstka., "*Network Centric Warfare: Its Origins and Future*," *US Naval Institute Proceedings*, 124, no. 1, January 1998, 35.

[78] Alberts, *Network Centric Warfare: Developing and Leveraging Information Superiority*, 175-176.

traditional hierarchical mechanisms for command and control – it is what allows them to synchronize their activities (behavior) from the "bottom-up".

Self-synchronization does not mean autonomous operations. ***It is the ability to control "bottom-up" emergent behavior within bounds*** which include commander's intent, doctrine, and anything that contributes to a common understanding of feedback.[79] These bounds are what help shape rule sets (internal models). Self-synchronization requires a break from our traditional view of control. Control in self-synchronization is about a common understanding of feedback made possible by general boundaries.

NAVY ADVANCED COMMAND AND CONTROL STUDIES

The Navy has conducted a series of warfighting experiments on self-synchronization.[80] These Advanced Command and Control Studies conducted by the Chief of Naval Operations Special Assistant for Strategic Planning (N6C), expanded on the elements required to make self-synchronization possible and applied them to military organizations. These experiments concluded that self-synchronization is a means for communicating the "mission critical dynamics" of the operations that "trigger" value adding interactions between subsystems.[81] The experiments also concluded that self-synchronization is possible in military organizations by:

1) ***Commonality in Operating Framework***. This commonality is accomplished through shared culture, doctrine, commander's intent, rules of engagement and

[79] Vice Admiral Arthur K Cebrowski, "*Network Centric Warfare: An Emerging Response to the Information Age*", Presentation at the Command and Control Research Technology Symposium, Naval War College, 29 June 1999, 4.

[80] Game I was a three day exercise conducted on board the U.S.S. Enterprise during April 2000. Game II was conducted in July 2000. The focus of Games I & II was on what factors shape command and control in the future (culture, organization and technology). Game III was a two week experiment conducted in December of 2000 at the Naval Postgraduate School. Game III attempted to answer the questions of "When does self-synchronization occur?" and "What conditions enable it?" Game IV was conducted in the spring of 2001 and was a follow up on the questions addressed in Game III.

shared processes and procedures developed during training.[82] A term that OPNAV N6C uses for this is "mutual mental model".[83]

2) ***Common Operating Picture***. Allows shared situational awareness throughout the organization of friendly forces, enemy forces and the operating environment.[84]

3) ***Trust*** (higher to lower and horizontally) defined as "the certain knowledge that other actors in the organization will interpret events and stimuli and react predictably in a particular situation."[85] Trust must exist horizontally between subordinate units. Subordinates must trust that other subordinate units will take the right action based on the common operating framework and common operating picture. Trust is reinforced by shared culture and shared training. It is also reinforced by the personal relationships that develop as a result of shared experiences. OPNAV N6C labels trust as the critical *prerequisite* for self-synchronization.[86]

4) ***Empowerment.*** In order to shorten decision cycles and maximize the potential benefits in speed of command made possible by a network, commanders must empower subordinates (made possible by the common operating framework and

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[81] Naval Post Graduate School, "*Advanced Command and Control (AC2) Game 3 Initial Insights Report*," <http://209.124.1.23/textac2/ AC2%20Game3-CDG1%20Initial%20Insights%20Report%20-%20Final.pdf> Accessed 1 September 2002, 2.
[82] Ibid, 5.
[83] Chief of Naval Operations, N6C, AC2 Study, *Game IV Report: Focus One: Self-Synchronization*, <http://cno-n6.hq.navly.mil/n6c/ac2/game4(final-3).pdf> Accessed 27 December 2002, 4.
[84] Susan G. Hutchins, David L. Kleinman, Susan P. Hocevar, William G. Kemple, and Gary R. Porter, *Enablers of Self-Synchronization for Network-Centric Operations: Design of a Complex Command and Control Experiment* (Newport, RI: Naval War College, 2000), 1.
[85] Chief of Naval Operations, N6C, AC2 Study, *Game IV Report: Focus One: Self-Synchronization*, 1.
[86] Ibid, 3.

common operating picture).[87] OPNAV N6C labeled empowerment as the "most critical attribute of self-synchronization."[88]

5) ***Commander's Role is Critical.*** Commanders must define overall mission goals and objectives. They also must create an organizational environment that provides a common operating framework (through training and shared culture). Lastly, as a result of common operating framework and the trust it creates, they are the only ones that can provide the "most critical attribute of self-synchronization" – empowerment.[89]

Command and control in a self-synchronizing organization is about creating the environment that allows emergent behavior and setting conditions that attempt to guide that emergent behavior in the direction that the commander desires.

> One military command and control concept that does not mesh well with complexity theory is synchronization...They [synchronization and Newtonian models] may work moderately well within those narrow parameters under which the system behaves relatively tamely. Synchronization falls flat when faced with a complex system which does not exhibit mechanistic dynamics. In fact, healthy complex adaptive systems tend to behave asynchronously - multiple agents acting independently of one another in response to local conditions. Complexity suggests the superiority of loosely coupled, modular plans which do not rely on synchronized control for their unity of effort [achievable now by networked force]. Such plans allow greater latitude in execution and, importantly, are more easily modified and repaired than synchronized ones. Where synchronization occurs, it should be the result of local cooperation between agents rather than of centralized direction.[90]

Self-synchronization is not necessarily a new concept. It is based on the same fundamental ideas that Major General John "Tiger Jack" Wood demonstrated with the 4th

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[87] Naval Post Graduate School, "*Advanced Command and Control (AC2) Game 3 Initial Insights Report"*, 5-6.
[88] Chief of Naval Operations, N6C, AC2 Study, *Game IV Report: Focus One: Self-Synchronization*, 7.
[89] Naval Post Graduate School, "*Advanced Command and Control (AC2) Game 3 Initial Insights Report"*, 5-6.
[90] John F. Schmitt "*Command and (out of) Control: The Military Implications of Complexity Theory*," In *Complexity, Global Politics, and National Security*, ed. David D. Alberts and T.J. Czerwinski (Washington, D.C.: National Defense University, 1997), 11.

Armored Division during World War II – decentralized command and control made possible by an organizational environment based on trust and empowerment and guided by mission orders and commander's intent. Self-synchronization, vice self-organization, is now possible because of advances in information technology and the capability the network provides - a universal situational awareness and ability to interact with any other unit / system / commander within the organization.

DIVISION CAPSTONE EXERCISE II

The Division Capstone Exercise (DCX) was a continuation of the work done during the DAWE. The 4th Infantry Division conducted two exercises as part of the DCX to demonstrate the warfighting capability of the Army's first digital division. Similar to the DAWE, observations from the DCX demonstrated that the Army's Force XXI operational and organizational concepts were valid and showed the advantages the Army could gain as a network-centric organization.[91] It showed that the 4th Infantry Division was capable of dramatic increases in combat power while being able to operate over a much larger area as a result of improved situational awareness provided by the network. The digital brigades of the 4th ID were capable of areas of operation of up to 1750 square kilometers.[92] Despite the dispersion caused by the increased area of operations, these brigades, enabled by increased situational awareness, were able to locate the OPFOR while remaining dispersed and then mass *lethal effects* at the time and place of brigade

[91] Force XXI concepts, as described in TRADOC PAM 525-5 showed that the Army understood the concept of self-synchronization as early as 1994. The possibility of self-synchronization, created by the ABCS network, was described as "…the expected contribution and initiative of better-informed soldiers, capable of individual action within the overall command intent. Such shared information, where, in some cases, subordinates have as much information as the commanders, changes the dynamics of leader-to-led in ways yet to be fully explored and exploited." Later the PAM makes another reference to self-synchronizing behavior made possible by the ABCS network saying "Combatants can often directly coordinate their actions better through shared situational awareness than a higher headquarters can by directive command." See TRADOC PAM 525-5 pages 3-4, 3-5, and 3-6.

[92] Lieutenant Colonel Jeffrey R. Witsken, "*Network-Centric Warfare: Implications for Operational Design*", (Fort Leavenworth, KS: United States Command and General Staff College, 2002) 33.

commander's choosing. Networked sensors (joint, division and brigade) which were linked to fire support elements (FSEs) initiated 232 of the 255 fire missions that met the commander's intent.[93] Increased situational awareness also allowed improved collaboration which "enabled commanders to quickly formulate COAs and to synchronize their efforts to defeat the enemy".[94] Although the Division operated with a traditional hierarchical command and control structure and concepts which did not allow self-synchronization, the potential was demonstrated through the ability of the division commander to command the division from any subordinate tactical operation center (TOC) since all subordinate TOCs had access to the same information as the division TOC because of the shared situational awareness provided by the network.[95] If the division commander had the ability to command from any subordinate TOC than the potential for self-synchronization exists.

Is the concept of self-synchronization feasible based on the concepts of future joint operational warfighting (JOW) and the Army's Objective Force? In order to make a determination we must first explore the concepts of JOW and the Objective Force and determine what the command and control requirements for those concepts are.

[93] U.S. Army Training and Doctrine Command, TRADOC Analysis Center, U.S. Army Training and Doctrine Command, *Final Report for the Division Capstone Exercise (DCX), TRAC-F-TR-02-006*, (Fort Leavenworth, KS: TRADOC, October 2001) 17.
[94] Ibid, 19.
[95] U.S. Army Training and Doctrine Command, TRADOC Analysis Center, U.S. Army Training and Doctrine Command, *Initial Insights Memorandum (IIM) for the Division Capstone Exercise Phase II (DCXII), TRAC-F-TR-02-004*, (Fort Leavenworth, KS: TRADOC, October 2001) 10.

CHAPTER 4 - JOINT OPERATIONAL WARFIGHTING CONCEPT

In order to make a determination if self-synchronization is feasible for future Joint and Army command and control concepts, a brief description of the elements of future Joint and Army operational concepts and their command and control requirements is needed. Before looking at how the Army envisions future operations with the Objective Force and its future concepts for command and control it is important to understand the future joint warfighting concepts which provide us an overarching joint perspective on future concepts for command and control. This section will describe Joint Forces Command's (JFCOM) evolving Joint Operational Warfighting (JOW) concept and then describe the JOW command and control concept - Adaptive Command. In the description of JOW's Adaptive Command concept the requirements that enable Adaptive Command will be listed and described.

Joint Operational Warfighting is the concept of how the joint force will fight in the future.[96] It is an expansion of the Rapid Decisive Operation (RDO) concept of joint warfighting and as such is full-spectrum and multi-dimensional. It is based on complexity theory, recognizing both friendly and enemy forces as complex adaptive systems. It is also based on a networked force, ideas from Network-Centric Warfare. The Joint Operational Warfighting concept paper states that the main theme of JOW is adaptability because of the recognition of the enemy as a complex adaptive system and because of the uncertainty inherent in the future operating environment.[97] The connectivity provided by the network provides the means for that adaptability. The JOW concept paper states that "the greater the degree of interconnectivity among elements of

[96] JOW is the joint warfighting concept for 2015 and beyond. U.S. Joint Forces Command, J9 Futures Lab, *Joint Operational Warfighting: Thoughts on the Operational Art of Future Joint Warfighting (Draft*), 15 August 2002, iii.
[97] Ibid, 25.

the joint force, the more adaptive it will be."[98] JFCOM's JOW concept paper describes the joint force as a force that succeeds in future warfare characterized by "complexity, confusion and chaos" and one that fights with "singularity, purposefully distributing of combat power against key enemy nodes and linkages."[99] Joint Operational Warfighting recognizes the power of knowledge-based warfare that requires the joint force acting in concert to create "unprecedented efficiency among the joint arms".[100]

This concept of future joint warfighting is made possible by the three cornerstones of JOW which are organized into ten "first principles" as follows:

Singular Battlespace
- Comprehensive Connectivity
- Freedom of Action
- Operational Perspective

Operations
- Joint Arms
- Distributed Combat Power
- Combinational Capability
- Spatial and Temporal Exploitation

Adaptive Command
- Shared Understanding
- Creativity
- Empowerment[101]

The key to Joint Operational Warfighting, as illustrated by the "first principles" is a "new paradigm for command [the cornerstone of Adaptive Command] that is built upon shared understanding, creativity and empowerment", many of the same requirements needed for self-organization and self-synchronization.[102] In order to understand this "new paradigm for command" we must first understand the cornerstones of future joint warfighting and their "first principles".

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[98] U.S. Joint Forces Command, J9 Futures Lab, *Joint Operational Warfighting: Thoughts on the Operational Art of Future Joint Warfighting (Draft*), 49.
[99] Ibid, VI.
[100] Ibid, 7.
[101] Ibid, 2.
[102] Ibid, V.

The first cornerstone of JOW is ***Singular Battlespace*** – "the fusion of joint arms into singularity".[103] Singular Battlespace is based on two things: the connectivity made possible by the network and complexity theory. It envisions using the ***comprehensive connectivity*** of the networked joint force to mass joint combat power against key nodes of the enemy (viewed as a complex adaptive system).[104] Comprehensive connectivity is not only based on technology and a common vision of the battlefield but also includes common frames of reference (training, doctrine, organizational structures etc.), characteristics that also enable self-organization and emergent behavior.[105] The concepts of self-organization and emergence, taken from complexity theory, are also visible in the "first principles" of operational perspective and freedom of action. ***Operational perspective*** relies on the "leader…trained to understand how his unit operates as part of the friendly system" allowing him to "adapt his actions and decisions toward the success of the system, not simply achieving short term tactical advantage."[106] The draft Joint Operational Warfighting concept paper says that "JOW aims at fostering this shift from tactical to operational perspective as emergent behavior within the future joint force, rather than on imposing it from above."[107] This shift to an operational perspective allows every element of the joint force to understand and focus on the operational plan which in turn maximizes the capabilities of the entire joint force. The JOW "first principle" of ***freedom of action*** is about facilitating adaptability through "joint warriors" who apply the elements of combat power "wherever and whenever they are needed ***within the bounds*** set by the Commander's Intent."[108]

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[103] U.S. Joint Forces Command, J9 Futures Lab, *Joint Operational Warfighting: Thoughts on the Operational Art of Future Joint Warfighting (Draft*), 26.
[104] Ibid, 21.
[105] Ibid, 22.
[106] Ibid, 24.
[107] Ibid, 24.
[108] Ibid, 25.

The second cornerstone of JOW, ***Operations***, includes the "first principles" of ***distributed combat power*** and combinational capability. Because of the shared awareness and connectivity provided by the network, the joint force, as envisioned in JOW, will be able to distribute combat power over a larger area by massing effects and not forces.[109] The JOW concept paper also says that the joint force must operate dispersed to be successful against a complex adaptive enemy that will avoid United States strength and operate dispersed.[110] The JOW concept paper states that the "first principle" of ***combinational capability*** is the "key to unlocking the full potential of the joint force."[111] Because of the interoperability and connectivity provided by the network JOW describes the joint force as being able to task organize quickly, "on the fly", depending on the mission – similar to the complexity theory concept of self-organization.

ADAPTIVE COMMAND

The command and control concepts that make Singular Battlespace and JOW Operations possible are included under the third cornerstone of JOW - ***Adaptive Command***. Adaptive command is the ability to quickly change command approaches, from highly centralized to totally decentralized, as the situation changes.[112] Adaptive Command consists of the JOW "first principles" of shared understanding, creativity, and

[109] U.S. Joint Forces Command, J9 Futures Lab, *Joint Operational Warfighting: Thoughts on the Operational Art of Future Joint Warfighting (Draft*), 34-35.
[110] Ibid.
[111] Ibid, 37.
[112] U.S. Joint Forces Command, J9 Futures Lab, *Adaptable Command and Control Concept (Draft)*. 26 August 2002, 18. The Adaptive command concept paper lists six command approaches that are borrowed from Alberts' *Understanding Information Age Warfare*, p. 170. These six "historical" command approaches are control-free, selective-control, problem-bounding, problem-solving, interventionist, and cyclic. Each of these six approaches is described in detail in the concept paper. Adaptive Command seems to envision a command and control concept that allows command approach to change very rapidly from control-free (which is referred to as self-synchronous in the Adaptive Command concept paper) to cyclic. This is not mentioned in the JOW concept paper, but it is made possible by the "first principles" of shared understanding, creativity, and empowerment.

empowerment.[113] The Joint Operational Warfighting concept defines ***shared understanding*** as "a common perspective and comprehension of the battlespace" throughout the joint force.[114] Shared understanding is a requirement of JOW's Adaptive Command and is only possible as a result of the comprehensive connectivity provided by the network.[115] Two other key enablers of shared understanding are commander's intent and feedback. Commander's intent helps to ensure unity of effort and "encourages innovation, creativity, and freedom of action" through loose bounds described in terms of the purpose of the operation.[116] Feedback, provided through the network, allows the commander to quickly adjust his commander's intent as the mission, enemy situation or operational environment changes.[117] JOW defines ***empowerment*** as autonomy of decision-makers within the bounds established by shared understanding.[118] These bounds include shared understanding of strategic and operational objectives, commander's intent and desired effects.[119] Empowerment, in the terms of Adaptive Command, is an attempt to influence emergent behavior while recognizing that

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[113] Both the JOW concept paper and the adaptive command concept paper define creativity but do not explain in detail what makes it possible – because of its cursory treatment in the JFCOM concept papers it is not explained in detail here.

[114] U.S. Joint Forces Command, J9 Futures Lab, *Joint Operational Warfighting: Thoughts on the Operational Art of Future Joint Warfighting (Draft)*, 45. In the draft Adaptive Command concept paper, the power provided by interconnectivity is explained as the ability to collaborate as "highly effective teams"– "…the heart of intelligent human performance is not the individual human mind in isolation but the interaction of the mind with tools and artifacts as well as groups of minds in interaction with each other." U.S. Joint Forces Command, J9 Futures Lab. *Adaptable Command and Control Concept (Draft)*, 26 August 2002, 2.

[115] U.S. Joint Forces Command, J9 Futures Lab, *Joint Operational Warfighting: Thoughts on the Operational Art of Future Joint Warfighting (Draft)*, 45. Many of the ideas about Adaptive Command are based on the connectivity of the joint force and are based on the concepts described in Network Centric Warfare.

[116] Ibid, 46.

[117] Ibid. The JOW concept paper uses ideas from complex adaptive systems in its discussion of feedback. The Adaptive Command concept paper describes feedback as the difference between the stated goals contained in the commander's intent and the situation., adaptive command, 5

[118] While often making references to complexity theory, specifically CAS and emergent behavior, the JOW concept paper does not mention self-organization. The JOW white paper which also borrows concepts from Network Centric Warfare does not mention self-synchronization. It does use the term "self-optimize" in discussions on task organization under the "first principle" of combinational capability. See JOW chapter on Adaptive Command, pages 42-47.

emergent behavior can not be a "command directed phenomenon."[120] Adaptive Command is based on allowing more freedom of action at the lower levels of the joint force and attempting to guide emergent behavior. The desired results of Adaptive Command, as envisioned in the Adaptive Command concept paper are enhanced collaboration, ***self-synchronization***, and the flexibility to seize opportunities as they emerge.[121] Command and control in JOW is about setting broad boundaries (organizational, geographical and dimensional) that set the conditions that allow freedom of action.[122]

The Joint Operational Warfare concept is based on the hypothesis that "the greater the degree of interconnectivity among the elements of the joint force, the more adaptive the force will be" and that elements of the joint force may no longer need to rely on traditional "hierarchical chains of command."[123] These are thoughts straight from complexity theory and Network Centric Warfare. The three cornerstones of JOW and their "first principles" are based on Network Centric Warfare and the concepts of self-organization and emergent behavior from complexity theory. JOW has, in its cornerstone of Adaptive Command, tried to broadly define a way to rapidly change command and control from centralized to decentralized (self-synchronous).

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[119] U.S. Joint Forces Command, J9 Futures Lab, *Joint Operational Warfighting: Thoughts on the Operational Art of Future Joint Warfighting (Draft)*, 48.
[120] Ibid, 48-49.
[121] U.S. Joint Forces Command, J9 Futures Lab. *Adaptable Command and Control Concept (Draft)*, 26 August 2002, 189.
[122] U.S. Joint Forces Command, J9 Futures Lab, *Joint Operational Warfighting: Thoughts on the Operational Art of Future Joint Warfighting (Draft)*, 22.
[123] Ibid, 49.

CHAPTER 5 - OBJECTIVE FORCE OPERATIONAL CONCEPTS

This chapter summarizes the operational concepts of the United States Army's Objective Force as described in the Operational and Organizational concept documents (O & O) for the Unit of Action (UA) and Unit of Employment (UE), highlighting key required capabilities as a prelude to describing the command and control concepts for the Objective Force as envisioned in TRADOC's ***Battle Command (C4ISR) for Army Forces in 2010 and Beyond (Version 4)***.[124] The Objective Force is described in the Objective Force Task Force White Paper's summary as a force that is:

1) Designed to cope with the new operational environment

2) More strategically responsive than current Army forces

3) Integrated within the joint force[125]

The O & O concept documents state that the hallmark of Objective Force operations is "the significant ability to develop situations out of contact, come at the enemy in unexpected ways" to "maneuver to positions of advantage with speed and agility, engage enemy forces beyond the range of their weapons, destroying them with enhanced fires, and assaulting at the times and places of our choosing".[126] These operations are possible because of the Objective Force's "quality of firsts" – "see first",

[124] TRADOC Pamphlet 525-3-90 describes UA concepts and TRADOC Pamphlet 525-3-92 describes UE concepts. The draft Battle Command concept paper will be published as TRADOC Pamphlet 525-3.0.1. This chapter does not discuss the organization of the Unit of Action or Unit of Employment and focuses instead on the operational concepts for both the UA and UE as background to a discussion on the current command and control concepts for the Objective Force. For reference the UA is envisioned as a brigade level equivalent and the UE is envisioned as a division or corps level equivalent.

[125] Description of the objective force from the concept summary in the Objective Force Task Force, *The Objective Force in 2015 White Paper Final Draft* (Arlington, VA: Department of the Army, 8 December 2002), i –ii.

[126] Ibid.

"understand first", "act first".[127] These "quality of firsts" are made possible by the following key characteristics of Objective Force operations[128]:

- Networked Structure (self-organizing network capability)[129]
- Empowerment[130]
- Modular Design[131]
- Adaptability (ability to transition "on the move")[132]
- Decentralized / Semi-autonomous Execution[133]

The Objective Force is a network-centric force.[134] The Objective Force's ability to "see first" is provided by networked intelligence, reconnaissance, and surveillance (ISR) sensors, organic, joint and national, which improve situational awareness within the

[127] U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-3-91: The United States Army Objective Force Tactical Operational and Organizational Concept for Maneuver Units of Action* (Fort Monroe, VA: TRADOC, November 2002), 50.
[128] Many of these characteristics of Objective Force operations are also listed as "required capabilities" in the UA and UE O & Os.
[129] U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-3-91: The United States Army Objective Force Tactical Operational and Organizational Concept for Maneuver Units of Action*, 151. The Objective Force Battle Command O & O describes in detail eleven characteristics of the network structure which include: unprecedented dependability, deployable, interdependent, interoperable, mobile, modular and scaleable, secure, self-configuring, self-healing, spectrum-efficient and survivable. See U.S. Army Training and Doctrine Command, Battle Command Battle Lab, *Battle Command (C4ISR) for Army Forces in 2010 and Beyond (Version 4) (*Fort Leavenworth, KS: TRADOC, 14 June 2002) F-5 – F-7.
[130] U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-3-91: The United States Army Objective Force Tactical Operational and Organizational Concept for Maneuver Units of Action*, 149.
[131] Ibid, 143.
[132] Ibid, 50.
[133] Ibid, 149.
[134] Joint/Army Concepts Directorate, Deputy Chief of Staff for Doctrine, Headquarters, US Army Training and Doctrine Command, *Objective Force Unit of Employment Concept (Final Coordinating Draft)* (Fort Monroe, VA: TRADOC, 7 August 2002) 33. The November 2002 Objective Force Whitepaper does not mention the term Network-Centric, but the December 2002 Whitepaper includes a section on "Network Centric Operations" under command and control, p. 15. The characteristics of a Network Centric force from Chapter 2 apply to the discussion here on the Objective Force. Network organization is a required capability (*TRADOC Pamphlet 525-3-91: The United States Army Objective Force Tactical Operational and Organizational Concept for Maneuver Units of Action*, 149). The OF UE O&O states that "The Unit of Employment is a knowledge-based force organized and designed to operate within the network-centric information environment of the future." *Objective Force Unit of Employment Concept (Final Coordinating Draft)*, 33.

organization.[135] In addition, the network links platforms and units so that the Objective Force shares a common perspective of the battlefield which includes information on friendly and enemy forces and the environment.[136] Improved situational awareness provided by a common operational picture allows the Objective Force to "understand first". Improved situational awareness provided by the network also allows the Objective Force to increase dispersion and mass combat power through "networked fires" within the UA and UE and with other joint and national enablers connected to the network.[137] The connectivity of the network and the increased situational awareness it provides also allows increased collaboration among Objective Force platforms and units which increases speed of command.[138] Increased connectivity and the common perspective of the battlefield it provides allows empowerment of subordinate leaders.

In the O & O for the Unit of Employment and Unit of Action empowerment is described in terms of "information empowerment" and "empowered understanding".[139] Information within the Objective Force can be distributed rapidly to all levels through the network so all units and platforms can share a common perspective of the battlefield. This common perspective of the battlefield "empowers understanding" by providing "leadership with access to external information

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[135] Joint/Army Concepts Directorate, Deputy Chief of Staff for Doctrine, Headquarters, US Army Training and Doctrine Command, *Objective Force Unit of Employment Concept (Final Coordinating Draft)*, 13.
[136] U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-3-91: The United States Army Objective Force Tactical Operational and Organizational Concept for Maneuver Units of Action*, 51.
[137] Ibid, 105. "Structurally and through the network, sensor-shooter relationships begin at the squad and platoon level throughout the formation to provide the ability to direct effects from internal UA elements, supporting UE forces, and joint assets…" (*TRADOC Pamphlet 525-3-91: The United States Army Objective Force Tactical Operational and Organizational Concept for Maneuver Units of Action*, 25).
[138] Ibid, pp. 80, 93.
[139] Ibid, pp. 52, 84.

that can be distributed rapidly to small units for greater operational effectiveness."[140] The UA O & O describes "greater operational effectiveness" as the ability of the Objective Force small units, through empowered understanding, to choose the time and location of the tactical fight allowing it to "act first".[141] The UA O & O briefly describes empowerment of tactical operations when discussing training and leader development to create soldiers and leaders who "are empowered to exercise uncommon initiative, based upon competencies in skill sets associated with warfighting."[142] It also lists "empowering decentralized execution and initiative by sub units" as a ***required capability*** for the Unit of Action.[143]

Another key characteristic of the Objective Force is the modularity of the Unit of Action brigade. The UA is modular in design so forces (capabilities) can quickly be added to it or taken away from it depending on the mission.[144] This is possible because of the network and the empowerment of subordinate leaders. The network facilitates rapid force tailoring by instantaneous access to shared situational awareness. This modular design of the UA brigade is also a ***required capability.***[145]

Because of the characteristics of the Objective Force listed above, the O & O states that the Objective Force will inherently be an adaptable force, able to quickly transition from one type of operation to another and "from one tactical engagement or battle to the next".[146] This will be possible because of the UA and UE's robust C4ISR network, and ability to access joint C4ISR capabilities that reside on the network.[147] The

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[140] U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-3-91: The United States Army Objective Force Tactical Operational and Organizational Concept for Maneuver Units of Action*, 24.
[141] Ibid, 57, 121.
[142] Ibid, 133.
[143] Ibid, 149.
[144] Ibid, 28.
[145] Ibid, 149.
[146] Ibid, 28.
[147] Joint/Army Concepts Directorate, Deputy Chief of Staff for Doctrine, Headquarters, US Army Training and Doctrine Command, *Objective Force Unit of Employment Concept (Final*

Battle Command O & O for the Objective Forces describes this as a "multi-layered network" and depicts it in the illustration below.

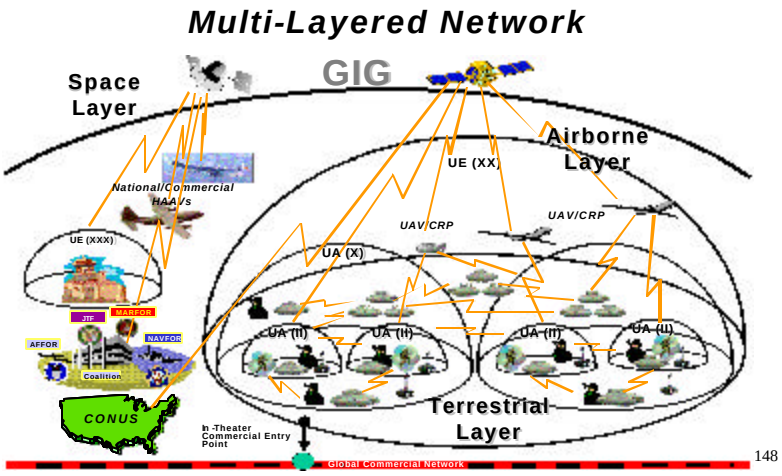

FIGURE 6: OBJECTIVE FORCE'S MULTI-LAYERED NETWORK

This robust networked C4ISR capability "builds and sustains superior knowledge" and allows the Objective Force to execute decentralized, semi-autonomous operations.[149]

The Objective Force is "a force deliberately designed for decentralized", non-linear operations.[150] The required capabilities of the network (specifically shared and improved situational awareness made possible by networked ISR), empowerment, and modular design are all needed in order to allow the Objective Force to execute these decentralized operations. The Unit of Action operates in a 75 kilometer area of operations and the Unit of Employment operates within a 500 kilometer area of

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Coordinating Draft), 33. The UE O & O describes the UE as a "knowledge-based C4ISR network of networks, vertically and horizontally integrated from the strategic level to the tactical level.

[148] U.S. Army Training and Doctrine Command, Battle Command Battle Lab, *Battle Command (C4ISR) for Army Forces in 2010 and Beyond (Version 4)*, F-3.

[149] U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-3-91: The United States Army Objective Force Tactical Operational and Organizational Concept for Maneuver Units of Action*, 28.

[150] Ibid, 26.

operations with the ability to influence out to 1000 kilometers.[151] This increased dispersion increases survivability and reduces risk to the force while the network, as already discussed, allows the massing of combat power (versus platforms) of the dispersed force. Because of its ability to operate in decentralized manner, the Unit of Action is able to "execute multiple engagements simultaneously and in rapid succession over a large area of operation."[152]

In order for the Objective Force Unit of Action and Unit of Employment to execute network-centric operations characterized by adaptability and decentralization, enabled by modular design and empowerment, requires new concepts for command and control. TRADOC's draft ***Battle Command (C4ISR) for Army Forces in 2010 and Beyond (Version 4),*** soon to be published as TRADOC Pamphlet 525-3-0.1, describes the battle command concepts required for Objective Force operations as envisioned in the UA and UE concept documents. The battle command concept paper is a collection of "10 Big Ideas" and the required capabilities that make those ideas possible. When taken together these "10 Big Ideas" describes the overarching concepts for Objective Force command and control.

[151] Joint/Army Concepts Directorate, Deputy Chief of Staff for Doctrine, Headquarters, US Army Training and Doctrine Command, *Objective Force Unit of Employment Concept (Final Coordinating Draft)*, 28.
[152] U.S. Army Training and Doctrine Command, *TRADOC Pamphlet 525-3-91: The United States Army Objective Force Tactical Operational and Organizational Concept for Maneuver Units of Action*, 92-93.

OBJECTIVE FORCE BATTLE COMMAND

The draft Objective Force Battle Command Operational & Organizational concept document, TRADOC Pamphlet 525-3-0.1, describes command and control for the Objective Force in terms of "10 Big Ideas" and the required capabilities for each of these "big ideas". The "10 Big Ideas" form the concept for future battle command that support the Unit of Action and Unit of Employment operational concepts as described in the previous section. These "10 Big Ideas", according to the Objective Force battle command concept, describe why Objective Fore battle command will be "qualitatively different" and are designed to help direct "our rethinking" of battle command.[153] According to the Battle Command O & O these "10 Big Ideas" are:

- **Commander Driven - Purpose Oriented - Knowledge Based - Mission Orders**
- **Echelonment of Command is not the same as Echelonment of Unit Formation**
- Battle Command Resources for Sustained Operations
- Battle Command - Anytime, Anywhere
- **Teaming of Commanders and Leaders - On Demand Collaboration**
- **Fully Integrated: Space to Mud, Factory to Foxhole**
- One Battle Command System
- **Unprecedented Information Network Dependability**
- Modular, Scaleable, Tailored Battle Command
- Dramatically Smaller Footprint[154]

The five main battle command "Big Ideas", as described in the Unit of Employment concept, are highlighted and discussed below along with their identified required capabilities as listed in the Objective Force Battle Command O & O. *Unprecedented*

[153] U.S. Army Training and Doctrine Command, Battle Command Battle Lab, *Battle Command (C4ISR) for Army Forces in 2010 and Beyond (Version 4)*, 2.
[154] Ibid, 7-8.

Information Network Dependability and a *Common Operational Picture* are required capabilities of all the battle command "Big Ideas" described below.[155]

Command Driven – Purpose Oriented – Knowledge Based – Mission Orders is based on the requirement to execute decentralized operations because of the widely distributed land operations executed by the Objective Force.[156] According to the Battle Command concept paper, Commander-driven battle command requires mission command. Mission command is the ability of subordinate units to take action independently, "guided by a clear understanding" of commander's intent.[157]

Echelonment of Command is not the same as Echelonment of Unit Formation is the ability of Objective Force organizations to task organize based on the requirements of the operation which includes the ability to dynamically task organize during operations.[158] According to the Battle Command concept "Higher headquarters will be organized and equipped to exercise Battle Command over highly flexible task organizations made up of…functional units of action."[159] In addition to the required capabilities of *Unprecedented Information Network Dependability* and a *Common Operational Picture,* a required capability that is specific to the idea of *Echelonment of Command is not the same as Echelonment of Unit Formation* is *Modular, Tailorable, and Reconfigurable Organizations.*[160]

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[155] U.S. Army Training and Doctrine Command, Battle Command Battle Lab, *Battle Command (C4ISR) for Army Forces in 2010 and Beyond (Version 4)*, pp. 10, 11
[156] Ibid, 7.
[157] Ibid, 9. Mission command is defined in FM 6.0 as "conducting military operations through decentralized execution based on mission orders for effective mission accomplishment. Successful mission command results from subordinate leaders at all echelons exercising disciplined initiative within the commander's intent to accomplish missions. It requires an environment of trust and mutual understanding. (1-15). LTC (R) William M. Connor, author of FM 6.0, says that FM 6.0 "establishes mission command as a C2 concept that best fits the doctrine of full-spectrum operations."
[158] U.S. Army Training and Doctrine Command, Battle Command Battle Lab, *Battle Command (C4ISR) for Army Forces in 2010 and Beyond (Version 4)*, 11.
[159] Ibid.
[160] Ibid.

Teaming of Commanders and Leaders – On Demand Collaboration is about improving speed of command and synchronization in distributed operations by allowing subordinate leaders to collaborate on planning and execution within the bounds set by the commander through mission orders. Collaboration is made possible by the common operational picture and communication provided by the network. This collaboration is envisioned as taking place often "without prompting of direction from senior commanders."[161] Collaboration will "blur the traditional hierarchy of command and function as control and direction of particular actions and forces shift" during operations. In addition to the required capabilities already discussed, "On Demand Collaboration" requires Joint Interdependent Battle Command and Virtual Teaming[162]

Fully Integrated: Space to Mud – Factory to Foxhole is the requirement for Army Objective Forces to be interdependent with joint forces and be able to operate "in a distributed fashion from home station to the point of decision."[163] The Objective Force battle command concept paper envisions a force that is no longer system-centric but based on an integrated force made possible by the network.[164] This integration is possible by the required capabilities of reach, sensor fusion, networked fires and joint distributed interoperable databases.[165]

Unprecedented Information Network Dependability is the backbone that allows Objective Force battle command, as envisioned in the battle command concept paper. It is provided by a mobile, multi-tiered, redundant and reliable network.[166] Key to this ultra reliable information network are the following required capabilities: Global Access to Global Information Grid (GIG) knowledge systems and services, multi- layered

[161] U.S. Army Training and Doctrine Command, Battle Command Battle Lab, *Battle Command (C4ISR) for Army Forces in 2010 and Beyond (Version 4)*, 15.
[162] Ibid.
[163] Ibid, 16.
[164] Ibid, 18.
[165] Ibid, 17.

communications architecture, self-healing and self-configuring network, and network components embedded in platforms.[167]

The preceding two sections have described the future Joint Operational Warfighting concept and the Army's Objective Force operational concepts. These sections have also described the future command and control concepts for those operational concepts – the joint concept of Adaptive Command and the Objective Force's battle command concept. By describing Adaptive Command and Objective Force battle command and the characteristics and requirements that enable those concepts it is now possible to compare those future command and control concepts with the concept of self-synchronization from Network-Centric Warfare. By making the comparison between the characteristics and requirements of self-synchronization and the characteristics and requirements of Adaptive Command and the Objective Force battle command concept it is possible to see if self-synchronization is feasible for future Joint and Army forces.

[166] Ibid, 20.
[167] U.S. Army Training and Doctrine Command, Battle Command Battle Lab, *Battle Command (C4ISR) for Army Forces in 2010 and Beyond (Version 4)*, 20.

CHAPTER 6 - ANALYSIS

Chapter 1 described complexity theory and the concepts of self-organization and emergent behavior. The nature of self-organization and emergent behavior was described as distributing control of an organization over the whole system which in turn allows decentralized control. The requirements and conditions for self-organization and emergent behavior were discussed as an introduction to the concept of self-synchronization. Chapter 2 described Network Centric Warfare and provided background on the theory of Network Centric Warfare in order to define the concept of self-synchronization. NCW envisions shared situational awareness, provided by a networked organizational structure, which allows increases in speed of command, dispersion and combat power. The chapter introduced self-synchronization where the behavior of an organization is controlled without detailed top down instructions. The chapter also described the requirements and conditions for self-synchronization, including self-organization and emergent behavior from complexity theory, which allow self-synchronization within a military organization. Chapter 3 described applicable future Joint and Army operational concepts, Joint Operational Warfighting (JOW) and the Objective Force, and the command and control concepts that each organization currently plans on using to execute those operations. These future command and control concepts, JOW's Adaptive Command and Objective Force Battle Command, were described in Chapter 3 in terms of their requirements and conditions ("first principles" or "10 Big Ideas" respectively). Having identified the requirements and conditions for self-synchronization, Adaptive Command and Objective Force Battle Command a comparison can be made to determine if self-synchronization is feasible for future Joint organizations and the Army's Objective Force.

DEFINITIONS

There is a distinction between shared awareness and shared understanding even though the terms are sometimes erroneously used interchangeably in literature dealing with information technology. Before making a comparison of self-synchronization, Adaptive Command and Objective Force Battle Command, the terms situational awareness, knowledge, and situational understanding should be reviewed and clearly defined.

- **Situational Awareness** (informational) is information of the current friendly and enemy situation and the environment. In self-synchronization, Adaptive Command and Objective Force Battle Command shared awareness is provided by the common operational picture.
- **Knowledge** (cognitive) is the ability to draw conclusions from patterns provided by available information (situational awareness). Knowledge can be pre-existing or accumulated (the 4th Armored Division's shared experience accumulated during training which enabled self-organization being an example).
- **Situational Understanding** (cognitive) is understanding what the current situation is becoming. It is the "ability to draw inferences about possible consequences of a situation". Simply stated situational understanding is the result of knowledge being applied to situational awareness.[168]

SELF-SYNCHRONIZATION MODEL

In order to determine the feasibility of self-synchronization for future operations as described in the JOW concept paper and the Objective Force operational concept papers, a comparison should be made between the requirements and conditions of self-

[168] David S. Alberts, J.J. Garstka, R.E. Hayes and D.A. Signori, *Understanding Information Age Warfare*, 17-20.

synchronization and the requirements and conditions for Adaptive Command and Objective Force Battle Command. The table below is a list of requirements for self-synchronization as described in Chapter 2:

NETWORKED ORGANIZATION

- COMMON OPERATING PICTURE (SHARED AWARENESS)

COMMON OPERATING FRAMEWORK

- SHARED CULTURE
- SHARED DOCTRINE
- COMMANDER'S INTENT
- SHARED PROCESSES AND PROCEDURES
- SHARED TRAINING
- SHARED EXPERIENCES

TRUST
EMPOWERMENT

SELF-ORGANIZATION

- OPEN SYSTEMS
- MANY PARTS
- LOCAL INTERACTION
- ADAPTATION
- NONLINEAR DYNAMICS
- EMERGENT BEHAVIOR
  - COMMON SENSE OF PURPOSE
  - COMMON "BUILDING BLOCKS" THAT CREATE:
  - COMMON "INTERNAL MODELS'

FIGURE 7: REQUIREMETNS FOR SELF-SYNCHRONIZATION[169]

The above requirements for self-synchronization can be grouped into four categories: 1) shared awareness (made possible by a networked organizational structure), 2) common operating framework, 3) trust and empowerment, and 4) complexity (self-organization and emergent behavior). These four categories can be applied to Boyd's Observe-Orient-Decide-Act (OODA) loop in order to provide a model for comparison.

[169] Based on Admiral Cebrowski's definition as quoted in Chapter two. This list expands on Cebrowski's definition including requirements and conditions from multiple sources on self-synchronization, as listed in Chapter 2, including those requirements from OPNAV N6C experiments.

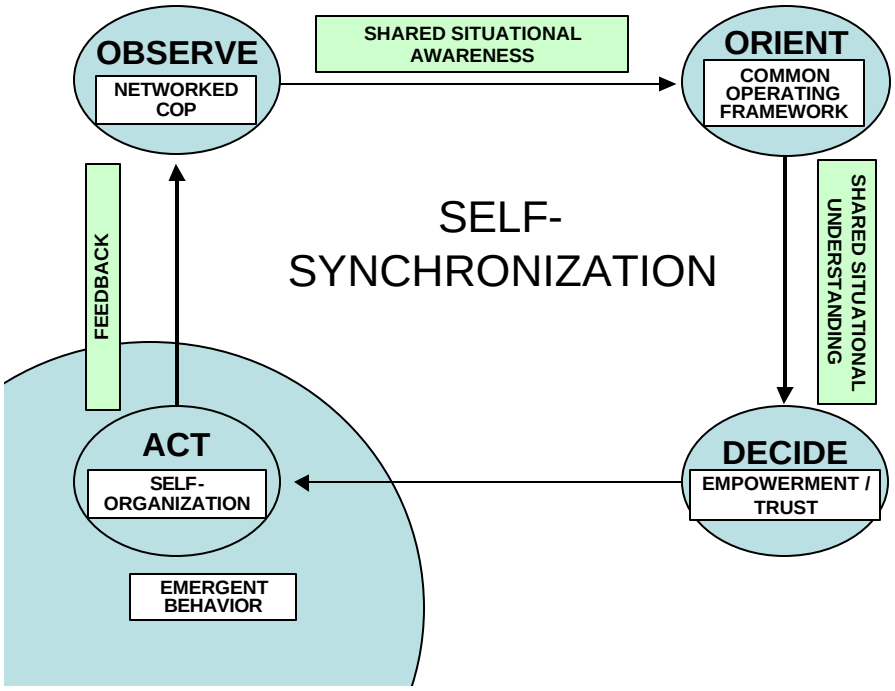

FIGURE 8: SELF-SYNCHRONIZATION REQUIREMENS & BOYD'S OODA LOOP

"Observe" includes inputs from the common operational picture provided by the network. The COP provides a shared situational awareness of the battlespace throughout the organization. "Orient" is accomplished by applying the information provided by the COP to the common operating framework. In self-synchronization, the common operating framework includes shared processes, procedures and commander's intent communicated through the network and shared culture, training, experiences and doctrine. The common operating framework is Cebrowski's "rule set" that bounds emergent behavior. The common operating framework, when applied to shared situational awareness leads to shared situational understanding. Shared situational understanding combined with empowered decision makers shortens the time required

during “Decide”. Independent subordinate organization decisions (within bounds set by the common operating framework and based on shared situational understanding) when aggregated lead to emergent behavior during “Act”. The requirements and conditions of self-synchronization explained using Boyd’s OODA loop provide a simple and useful model for comparing self-synchronization, Adaptive Command and Objective Force Battle Command.

ADAPTIVE COMMAND MODEL

The requirements of Adaptive Command, as described in Chapter 3 include the JOW “first principles” of shared understanding, creativity and empowerment. These “first principles” and their requirements and conditions have many similarities with the requirements and conditions of self-synchronization listed in Figure 7. These similarities are not coincidental and are the result of two things. First, both self-synchronization and the Joint Operational Warfighting concept are based on complexity theory’s concept of emergent behavior. Second, both self-synchronization and JOW require a comprehensive networked organizational structure in order to establish shared awareness. Similar to self-synchronization, Adaptive Command’s shared understanding is produced by a common frame of reference (i.e. doctrine, training and commander’s intent) and shared situational awareness provided by the common operational picture on the network. Empowerment, as envisioned in Adaptive Command, is about “guiding” emergent behavior through establishment of bounds provided in the form of commander’s intent and shared understanding of objectives, the same idea of “guiding” emergent behavior as in self-synchronization as illustrated in Figure 8.

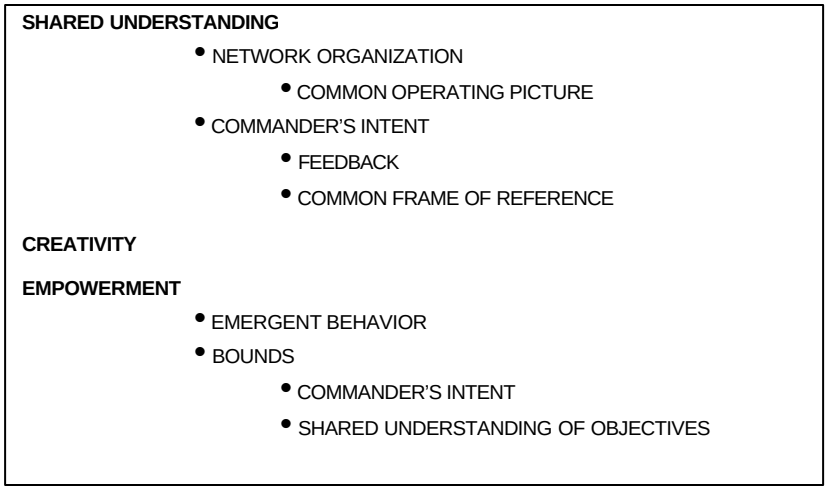

FIGURE 9: REQUIREMENS OF JOW'S ADAPTIVE COMMAND

The similarities between self-synchronization and Adaptive Command are not surprising since both concepts are based on complexity theory and the theory of Network-Centric Warfare. Self-synchronization is possible with Adaptive Command and is **feasible** for Joint Operational Warfighting. In fact, one of the desired results of Adaptive Command, as envisioned in the Adaptive Command concept, is ***self-synchronization***.[170]

OBJECTIVE FORCE BATTLE COMMAND

Similarities between self-synchronization and the Objective Force Battle Command concept are not as clear. The majority of Objective Force Battle Command requirements are based on specific technological capabilities that often do not easily translate to functional capabilities as can be seen in Figure 10 below.[171]

[170] U.S. Joint Forces Command, J9 Futures Lab, *Adaptable Command and Control Concept (Draft)*, 189.
[171] Of the "10 Big Ideas", **Commander Driven-Purpose Oriented-Knowledge Based-Mission Orders** is the only idea not based on technology.

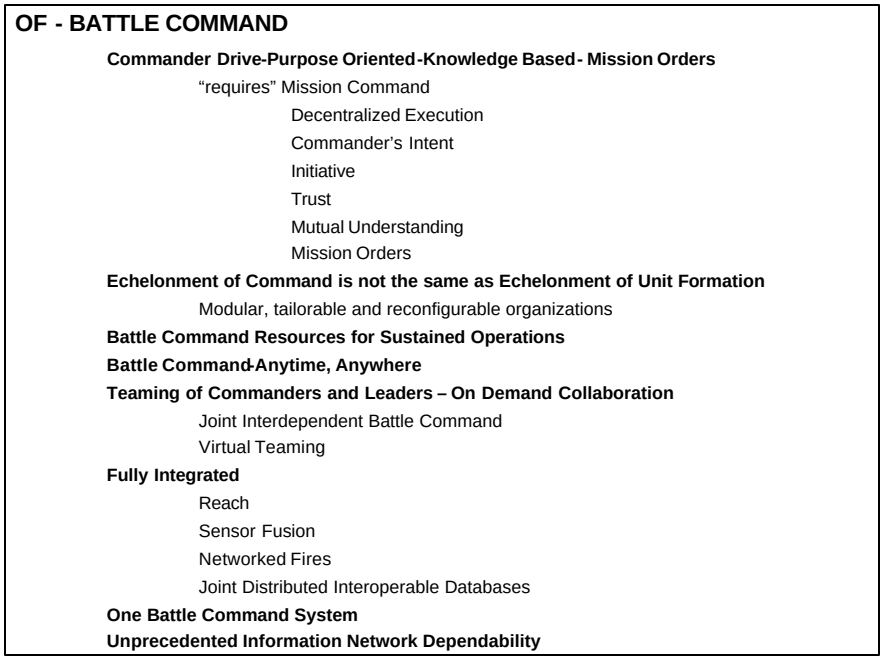

FIGURE 10: OBJECTIVE FORCE BATTLE COMMAND'S "10 BIG IDEAS"

As in the previous comparison between Adaptive Command and self-synchronization, the visual model of self-synchronization is useful for comparing Objective Force Battle Command and self-synchronization. The "Big Ideas" of *Unprecedented Information Network Dependability, Fully Integrated* concepts of sensor fusion and joint distributed database and *Battle Command-Anytime, Anywhere*, all contribute to "Observe". These "Big Ideas" are what provide a shared common operational picture of the battlefield within the Objective Force that leads to shared situational awareness. The "Big Ideas" of *One Battle Command System*, the concepts that allow "modular, tailorable and reconfigurable organizations" of *Echelonment of Command is not the same as Echelonment of Unit Formation*, and the concepts that all *Teaming of Commanders and Leaders – On Demand Collaboration*, all contribute to providing a common operating framework. As in self-synchronization this common operating framework when applied

to shared situational awareness leads to shared situational understanding within the Objective Force. The Objective Force Battle Command "Big Idea" of *Commander-Driven Purpose Oriented-Knowledge Based-Mission Orders* consists of concepts that influence both "Orient" and "Decide". Within "Orient" commander's intent, as in self-synchronization and Adaptive Command, helps shape the common operating framework that takes shared situational awareness and helps develop it into shared situational understanding.[172] Within "Decide" elements of mission command, empowerment and trust (allowing decentralized operation through subordinate initiative), in combination with shared situational understanding shortens the time required in traditional hierarchical, non-networked organizations. The above comparison of the Objective Force Battle Command concept and self-synchronization shows that the requirements for the two command and control concepts are similar and that self-synchronization is feasible for the Objective Force.

Recent Objective Force experiments illustrate that Objective Force Battle Command concepts demonstrate self-synchronization. From April to November of 2002 TRADOC Analysis Center conducted an experiment of Objective Force C4ISR. Understanding that the Objective Force O & O's are conceptual and evolving, as a result of the experiment many of the Objective Force concepts were identified as needing more refined concept articulation by the analysts. One of the major issues identified as needing further development was the Objective Force concept of "networked fires". The concept expectation was that the COP would allow the linkage of any sensor to any shooter within the organization. During the experiment the Objective Force COP provided shared situational awareness and the commander's guidance for fires and

[172] Current Army doctrine, FM 6.0, Command and Control, lists the principles of command as unity of effort, decentralized execution, trust, mutual understanding, timely and effective decisionmaking (possible by empowerment, initiative and trust). These principles of command

engagement parameters developed by the Fires Effects Center (FEC) provided the common operating framework or "rule set". Once a target was identified, any unit or platform could destroy that target, through "networked fires" using any shooter within the organization. During the experiment the Objective Force concept of "networked fires" demonstrated self-synchronizing behavior.

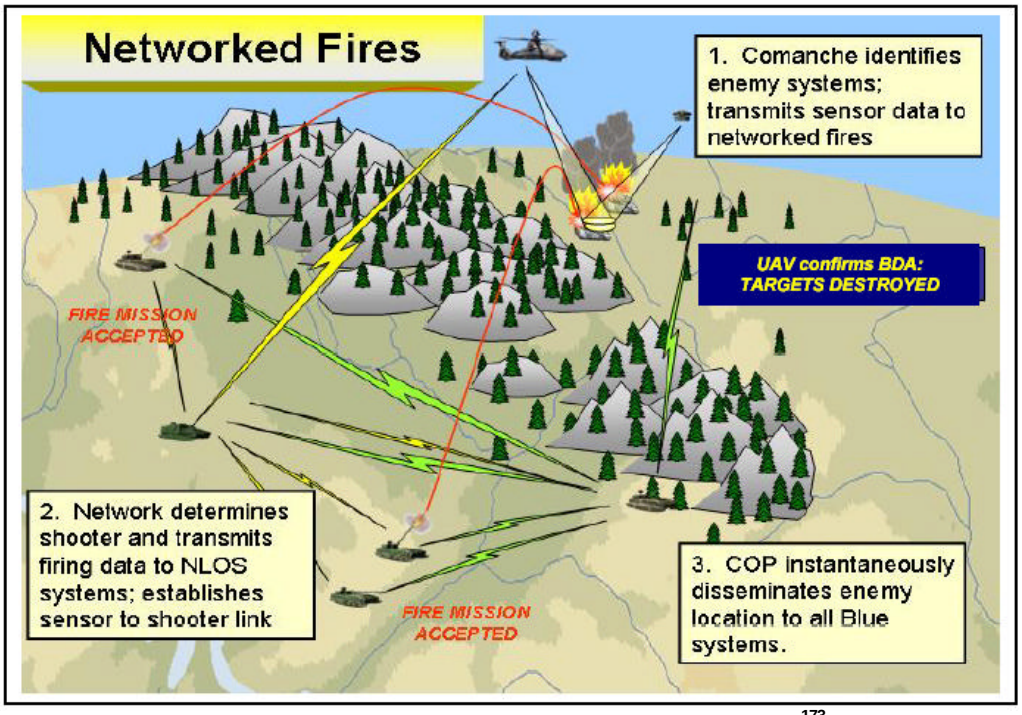

FIGURE 11: OBJECTIVE FORCE NETWORKED FIRES[173]

The results of the experiment showed that the "networked fires" concept resulted in unfocused application of effects because of: 1) the availability of significant targetable

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are the same as the elements of the "Big Idea" of *Commander Driven-Purpose Oriented-Knowledge Based-Mission Orders.*

[173] U.S. Army Training and Doctrine Command, TRADOC Analysis Center, U.S. Army Training and Doctrine Command, *Objective Force/Future Combat Systems C4ISR Experiment Initial Insights Report* (Fort Leavenworth, KS: TRADOC, February 2003) 31.

data on the unit COP and 2) unconstrained access to all available fires.[174] There was a lack of understanding how to properly set bounds through a common operating framework to maximize the effectiveness of self-synchronizing behavior. The results of the Objective Force C4ISR experiment show that self-synchronizing behavior was demonstrated during execution of "networked fires". The Objective Force C4ISR experiment also demonstrated some of the potential problems associated with self-synchronization.

ISSUES AND RECOMMENDATIONS

Although self-synchronization is feasible for future Joint and Army forces, it is still ***conceptual*** and there are many unresolved issues that require further study before self-synchronizing behavior will be effective and acceptable under the command and control concepts of Adaptive Command and Objective Force Battle Command.

The first issue is the danger of using shared situational awareness and understanding provided by network technology to centralize control rather than effectively empowering subordinates[175]. Field Manual 6.0, Command and Control, warns against the danger of using technology to control "the actions of an individual soldier at any time."[176] This tendency is not new and has been demonstrated throughout history.[177] Recent Joint and Army warfighting experiments as documented this

[174] U.S. Army Training and Doctrine Command, TRADOC Analysis Center, U.S. Army Training and Doctrine Command, *Objective Force/Future Combat Systems C4ISR Experiment Initial Insights Report*, 16.
[175] Empowering subordinates includes empowering through knowledge provided by shared situational understanding and empowering with the ability to apply combat power of the entire force without detailed top-down instructions.
[176] U.S. Department of the Army, *FM 6-0 Command and Control (DRAG)* (Washington, D.C.: Government Printing Office, 2001) 1-17.
[177] Two historical examples are the British reliance on the telegraph and telephone for centralized control during World War I [to the point that battalion commander's did not leave their command posts for fear of missing a phone call] and the United States use of the command and control helicopter during the Vietnam War where "a hapless company commander engaged in a firefight on the ground was subjected to direct observation by the battalion commander circling above,

tendency. The solution to this problem is as simple as understanding and following our current doctrine. Current Army doctrine recognizes that good decisionmaking at the lowest levels allows an organization to operate faster than a force that uses centralized control.[178] One of the tenets of Army operations is initiative which requires "delegating decision making authority to the lowest practical level."[179] FM 6-0 recognizes mission command as the preferred method of command and control and discusses the requirements for successful mission command. It also recognizes that network technology maximizes the potential of a mission-command concept.[180] Maximizing the potential of information technology through increasing speed of command is only possible if it is used to empower subordinates.

The second issue is the reciprocal of the first. Establishing bounds to guide emergent behavior of an organization involves significant risk if not understood properly and requires a dramatically new way of thinking about command and control. Self-synchronization may also not be appropriate for every situation or operation as demonstrated during the recent Objective Force C4ISR experiment. A commander must be able to control subordinates if required. Errors can occur or the situation may require centralized control. It will always be important for the commander to have some means to monitor and impose hierarchical control when the situation requires. The danger with centralized monitoring is ability and tendency to exercise centralized control (goes back to issue number one).

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who was in turn supervised by the brigade commander circling a thousand or so feet higher up, who was in his turn monitored by the division commander in the next highest helicopter…". See Martin Van Creveld's *Command in War* Chapter 5, *The Timetable War*, pp. 148-188 and Chapter 7, *The Helicopter and the Computer*, pp. 232-260 respectively.

[178] Field Manual 3-0 states that "the capabilities of new information systems encourage subordinates to exercise disciplined initiative…" and also states that "A force in which commanders make good decision at the lowest level will operate faster than one where decisions are centralized." See pages 11-23.

[179] U.S. Department of Army, *FM 3-0 Operation* (Washington, D.C.: Government Printing Office, 2001) 4-15.

[180] U.S. Department of the Army, *FM 6-0 Command and Control (DRAG)*, 1-17.

The last issue is understanding how to effectively establish a common operating framework. This is not a new problem and it consists of two parts. First, is an understanding of emergent behavior, a field which is new and requires further research in order to have utility to the military.[181] The common operating framework creates the bounds that "guide" behavior. It allows information provided by the common operational picture to be translated into shared situational understanding that contributes to decisions that "guide" emergent behavior of an organization. Second, it requires further research into how we make decisions. The common operational picture is based on individual perception, even within the bounds of the common operating framework. How we process shared situational awareness into shared situational understanding and how that shared situational understanding contributes to emergent behavior is central to understanding self-synchronization and how to make it work effectively. Examples of commanders understanding traditional means to achieve a common operating framework based on doctrine, TTP, education and training have been demonstrated throughout history - General John P. Wood and his 4th Armored Division in World War II described in Chapter One being just one example

The above comparison of self-synchronization, Adaptive Command and Objective Force Battle Command show that all three attempt to increase speed of command and ultimately speed of execution, by shortening the time required during "Observe" and "Orient" by using shared situational awareness provided by the network. All three attempt to shorten the time required during "Decide" by using elements of mission command and shared situational understanding. By comparing the requirements and characteristics of all self-synchronization, Adaptive Command and Objective Force Battle Command, self-synchronization has been shown to meet future

[181] Further research is also required to make complexity theory and emergent behavior understandable and acceptable to the military as well.

Joint and Army command and control requirements demonstrating it's feasibility for future Joint and Army forces. While there are several issues with using self-synchronization that must be addressed, future Joint and Army experimentation will continue to illustrate examples of self-synchronizing behavior and it's potential.

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